(12)

AD-E500 618

Copy 61 of 200 copies

AD A138282

IDA RECORD DOCUMENT D-49

REPORT OF FINDINGS AND RECOMMENDATIONS-- SOFTWARE ENGINEERING INSTITUTE STUDY PANEL

Neil S. Eastman, *Panel Chairman*

December 1983

Prepared for

Office of the Under Secretary of Defense for Research and Engineering

DTIC FILE COPY

INSTITUTE FOR DEFENSE ANALYSES
COMPUTER & SOFTWARE ENGINEERING DIVISION

84 02 16 066

IDA Log No. HQ 83-28304

The work reported in this document was under contract MDA 903 79 C 0018 for the Department of Defense. The publication of this IDA Record Document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that agency.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A138 382	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Report of Findings and Recommendations-- Software Engineering Institute Study Panel		5. TYPE OF REPORT & PERIOD COVERED Final -- May to Oct.1983
		6. PERFORMING ORG. REPORT NUMBER IDA Record Document D-49
7. AUTHOR(s) Neil S. Eastman, Panel Chairman		8. CONTRACT OR GRANT NUMBER(s) MDA 903-79-C-0018
9. PERFORMING ORGANIZATION NAME AND ADDRESS Institute for Defense Analyses 1801 N. Beauregard Street Alexandria, VA 22311		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Task T-3-189
11. CONTROLLING OFFICE NAME AND ADDRESS ODUSD (R&AT) The Pentagon Washington, DC 20301		12. REPORT DATE December 1983
		13. NUMBER OF PAGES 46
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) DoD-IDA Management Office 1801 N. Beauregard Street Alexandria, VA 22311		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

Statement A

Approved for Public Release; Distribution Unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

IDA RECORD DOCUMENT D-49

REPORT OF FINDINGS AND RECOMMENDATIONS-- SOFTWARE ENGINEERING INSTITUTE STUDY PANEL

Neil S. Eastman, *Panel Chairman*

December 1983

INSTITUTE FOR DEFENSE ANALYSES
COMPUTER & SOFTWARE ENGINEERING DIVISION
1801 N.Beauregard Street, Alexandria, Virginia 22311

Contract MDA 903 79 C 0018
Task T-3-189

FOREWORD

This report constitutes the findings of the Software Engineering Institute Study Panel chaired by Mr. Neil Eastman of IBM. After the initial meetings of this panel and upon advice of the DoD General Counsel that joint Government private sector participation might be inconsistent with the Federal Advisory Committee Act PL 92-463, the Government panel members were excused from further participation. Therefore the membership of this panel is non-governmental and the findings must be interpreted in this light.

The members of the panel have reviewed and endorse the panel recommendations.

Thomas H. Probert
Director,
Computer and Software Engineering Division

A-1

PREFACE

Mission-critical computer software systems have been growing larger, more complex, and much more expensive. The Electronics Industries Association has predicted that, at current productivity levels, software will consume 10% of the defense budget by 1990. Today, neither our budget nor our technical capability is adequate to support the rapid growth in applications that we are experiencing. The all-too-frequently observed symptoms are: (1) weapon system schedule slips due to software problems; (2) system failures due to software bugs; (3) software cost overruns; and (4) a nationwide shortage of software professionals.

At least six Defense Science Board Task Forces and USDRE independent review committees plus the Air Force Scientific Advisory Board have recently reinforced and emphasized the need for extensive, specific and coordinated DoD sponsored software activities to resolve the problems in software.

In 1982, the Deputy Under Secretary of Defense (R&AT), with the support of the Assistant Secretary of the Army (RD&A), the Assistant Secretary of the Navy (RE&S), and the Assistant Secretary of the Air Force (RD&L), formed a DoD Joint Service Task Force on software problems to review the problems in DoD Embedded Computer Software and to assess the impact these problems have on the U.S. military mission. Their report, completed in July 1982, reinforced the view that there are many difficulties facing DoD in software. Many examples are cited illustrating that the problems are severely affecting the cost, deployment schedules, as well as the utility of deployed weapon

systems. The Task Force recommended that a comprehensive software initiative be undertaken.

A Joint Task Force, working from October 1982 to March 1983, proposed a Strategy for the "Software Technology for Adaptable, Reliable Systems" (STARS) program, to address the critical software situation. Contained within the report of the Task Force is a proposal for the establishment of a Software Engineering Institute (SEI) to bridge the gap between R&D activities that demonstrate new techniques and the exploitation of those techniques in system developments in order to effect a significant and rapid improvement in the means of development and support of computer software for mission-critical defense systems. The Task Force also prepared a separate report entitled "A Candidate Strategy for the Software Engineering Institute" which discusses proposed operational characteristics and organizational and management alternatives.

The establishment of such an organization is a bold undertaking. To obtain an independent assessment of this recommendation, OSD, with the support of the Services, formed a "Blue Ribbon" Panel from industry and academia to study whether or not such an institute was necessary and, if so, to prepare preliminary statements of mission and function, and to develop criteria for site selection. The Panel completed its work. This report is the result.

E. Lieblein
Acting Director
Computer & Software Systems

Report of Findings and Recommendations
Software Engineering Institute
Study Panel

October 21st, 1983

PREFACE

SOFTWARE ENGINEERING INSTITUTE STUDY PANEL

Charter

The purpose of the Software Engineering Institute Study Panel (SEISP) is to provide assistance to the Deputy Under-Secretary of Defense (Research and Advanced Technology) (DUSD(R&AT)) in defining the mission, responsibilities and options for implementation of a DoD Software Engineering Institute as proposed in the STARS Joint Service Task Force Program Strategy, April 1, 1983. The Institute for Defense Analyses (IDA) assembled the panel at the request of the DUSD(R&AT).

The initial basis for SEISP deliberations was the Software Technology for Adaptable, Reliable Systems (STARS) Program Strategy document issued by the Department of Defense, 1 April 1983. DUSD(R&AT) instructions to the SEISP were to challenge any assumptions regarding a potential Software Engineering Institute that the SEISP deemed questionable and to recommend any functionally equivalent or alternative strategies that better serve STARS goals.

Membership

The SEISP was composed of members from the academic community and the private sector. Appendix A contains a list of members. Representatives of the Department of Defense and the Services served in an advisory role.

Consensus

The SEISP members unanimously endorse the conclusions and recommendations contained in this report. The first and most important conclusion is that a Software Engineering Institute is essential to achieving STARS goals and must be established with the greatest possible speed.

CONTENTS

1.0 SUMMARY OF FINDINGS AND RECOMMENDATIONS

1.1 PRINCIPAL RECOMMENDATIONS AND RATIONALE

The SEISP finds that a Software Engineering Institute is essential to achieving STARS goals and must be established with the greatest possible speed.

The SEISP accepts and reinforces the consensus that mission critical system software is rapidly becoming a controlling factor in defense and weapon system capabilities. STARS goals are to increase software productivity and simultaneously to significantly improve software adaptability and reliability, achieving integral factors of improvement by the end of this decade. These goals require major and rapid improvements in software engineering practice and of necessity in the technologies that enable improved practice. Computer programming is barely thirty years old and only recently have scientific foundations begun to emerge. There is a compelling need to develop a mature discipline faster than has ever been done before in any field of engineering.

The SEISP is convinced of the primary importance of software techology insertion in this maturing process. Promising technology potential exists in universities, in research and development organizations and in commercial enterprises. Mission critical applications impose severe requirements upon supporting technologies that few existing or developing technologies can directly meet. Economic and societal factors tend to damp rather than foster the propensity to spontaneous technological change. A sustained and dedicated effort to accelerate software technology insertion is required. High-payoff, mutually-supportive technologies must be selected, engineered to mission critical scale and quality and applied as standard practice throughout the MCCR software community.

The Software Engineering Institute proposed in this report must focus on improving the actual practice of DoD software development and support by inserting modern technology into the life-cycle process. To accomplish its mission the Institute will:

- Seek out appropriate technology and adapt and engineer it to MCCR production quality and scale

- Provide the funds, the talent and the support to selected MCCR projects to permit them to utilize the best available technology in developing their software systems

- Establish a standard of excellence in software engineering practice and become a source of top quality assistance and

support for the entire MCCR development and support community

The SEISP recommends that a responsibility of maximum priority during the first one to two years of Institute operation be to establish an effective strategy for inserting technology into private MCCR software contracting enterprises. The avenues that the Institute can exploit to influence DoD components are much richer than those available to influence private, autonomous businesses. Such a strategy is on the critical line of Institute success.

Approximately 60% of Institute resource should be devoted to achieving rapid reduction to practice of software engineering tools, methods, techniques, processes and environments; 20% of resource should directly support the Services and DoD components; 10% should be dedicated to education and training and 10% should be devoted to goal-directed research.

1.2 IMPLEMENTATION RECOMMENDATIONS AND CRITERIA

The SEISP recommends that a new entity be created. No existing organization was found to be entirely adequate to assume Institute responsibilities. The Institute should be a dedicated, non-profit corporation, associated with one or more leading universities and for the first several years both organizationally and geographically centralized. Other institutional models were considered and found to be less satisfactory.

Choice of location should be guided by proximity to a metropolitan area, a transportation hub, a university, ready sources of professional and support staff, ready availability of physical plant and facilities and by security from external sources of interference and intrusion.

The DoD Computer Software and Systems (CSS) Directorate should provide the focal point of DoD oversight. A Board of Visitors composed of distinguished technical leaders from universities, industry and Government should be appointed to assess Institute accomplishments.

Total budget should be provided by baseline funding through a lead-Service omnibus contract supplemented by direct Service funding for Institute services and products. The SEISP projects the following staffing and budget levels as minimums to accomplish Institute objectives:

YEAR	1	2	3	4	5	6
Staff	80	130	180	220	250	250
Baseline $M	8	12	15	20	20	20
Service $M	-	3	5	8	13	13
Total Budget	8	15	20	28	33	33

The SEISP explored four alternative Institute start-up strategies but did not make an explicit selection, except to strongly recommend that speed be a priority consideration.

Three issues critical to STARS success but not critical to initiation of the Software Engineering Institute were discussed but not resolved: protection of proprietary rights, protection of militarily critical technical data and relationships with private industry.

2.0 PROBLEM STATEMENT

The SEISP accepts and reinforces the Joint Service Task Force conclusion that mission critical system software is rapidly becoming a controlling factor in defense and weapon system capabilities. This report section summarizes the factors in the current situation, the future needs, the opportunities and the impediments that form the environment and the rationale basis for the Software Engineering Institute.

2.1 THE SOFTWARE SITUATION

Excerpts from the Journal of Defense Systems Acquisition Management and the STARS Program Strategy outline a growing need:

"... an idea that is only now being realized - that software is a system. It is no longer merely a part of a system, but a system that performs the integration functions for the systems, whether they are avionics, or missiles, or command and control functions. Integration of system functions is now found in the information domain and, as a result, ever-increasing attention must be given to management to avoid the extension of the software cycle in the normal pattern."[1]

"Software is the essential element that controls, even defines, the system. Software is the embodiment of system "intelligence." In addition, it provides the flexibility to respond to changing threats, needs and requirements. ... Development and support of software for major military systems is one of the most complex of human endeavors, often requiring hundreds of people for five or more years at costs exceeding $100 million (e.g., the B-1, Aegis and Safeguard systems). The demand for software is escalating rapidly. Software is often on the system critical path, often late and over budget - the costs for software sometimes even dominate the project cost. To compound the situation, the supply of trained professionals is inadequate."[2]

Computer programming is barely thirty years old. Only recently have scientific foundations for software engineering begun to emerge. But during this thirty years there has been an enormous programming population growth, accompanied by an equally enormous accumulation of software inventory created by programming art rather than by scientific or engineering disci-

---

1 "DoD Policy for ECR," H. Mark Grove, Concepts Vol. 5 No. 4, Autumn 1982.

2 STARS Program Strategy, Department of Defense, 1 April 1983, Executive Summary

pline. Of the perhaps fifty thousand[3] programming people involved with defense software, only a minority have had formal exposure to recent software engineering ideas. Of the millions of lines of software in current defense systems, only the more recent have been created according to modern software engineering principles. The past dominates the present, prevailing over new approaches and the ideas of entrants new to the community.

There is consensus throughout the industry that to achieve major improvements in the qualities of delivered software, there must be major improvements in practice and, of necessity, in the technologies that enable improved practice.

The goal of the STARS program is to "... improve software productivity while achieving greater system reliability and adaptability."[4] Attainment of that goal is absolutely dependent upon engineering software technologies to mission critical requirements and inserting such technologies into universal practice.

Within the STARS six-year time frame,

- new technology capabilities must be engineered to mission critical production quality and scale,

- engineered technologies must be integrated into DoD organic environments and industrial development environments, and

- high standards of software engineering practice and software product quality must be established and required throughout the Defense software community.

2.2 THE TECHNOLOGY SITUATION

There is an increasing flow of new and promising ideas for software engineering technologies -- methods, techniques and support systems -- but the bulk of these are grown from idealistic rather than practical environments and their utility is demonstrated on "toy" examples. Yet the greatest difficulties often lie in scaling demonstration prototypes to system-sized applications. These difficulties may be even more challenging than concept origination itself, but meeting the untidy, pragmatic tests of large-scale application has little theoretic

---

3 Estimated DoD MCCR software expense of $5 - $6 billion and annual per-head costs in the neighborhood of $100 thousand suggest on the order of 50,000 software practitioners.

4 STARS Program Strategy, Department of Defense, 1 April 1983, Executive Summary

appeal. Software development and support technologies developed for internal purposes may exist in many enterprises, but they are neither visible to the Defense community nor likely to be easily transportable.

The experience base of today's software population lies in practicing an immature, labor intensive discipline to create complex software systems by manual effort and art. There is at least the comfort of familiarity, if not complete satisfaction, with today's practice; as long as the job seems to get done, stability is preferable to the potential discomfort of change. Software professionals valued for their experience have a vested interest in continuing the basis of that experience. As long as contracts are won and deliverables are accepted, management perceives little recessity to invest in upsetting the status quo.

There is a gulf between the practicing population and the potential of existing and nascent software technologies. Building a bridge between these two worlds is the challenge of *software technology insertion.*

2.3 SOFTWARE TECHNOLOGY INSERTION

The SEISP is convinced of the primary importance of *software technology insertion.* This section outlines the SEISP's understanding of the necessary elements of the software technology insertion process.

The process has two origination points: a *need* that stimulates the search for and engineering of technology that satisfies the need, or a recognition of a technology *capability* that may bring novel improvements in areas where practitioners have not yet precisely articulated needs. In both cases, the decision to initiate the process must be governed by *assessment* of the value of the technology in practice.

Regardless of stimulus, the technology insertion process follows essentially this course:

- adaptation and engineering of the technology to MCCR production quality and scale,
- identification, guidance and support of initial users,
- evaluation of the results of initial use, and
- expansion and support of the using community.

The process must draw upon an extensive pool of technology to select and to develop appropriate solutions to specific needs.

A new capability may arise from anywhere within the software community; sources may range from publication of research results to the appearance of a novel commercial product. Particularly in the case of new capabilities, insertion opportunities and payoff potential may be difficult to calibrate with metric precision. Selection of the most promising opportunities for full scale development requires continuing assessment and expert judgment.

The potential user base is well known for need-driven insertion. For capability-driven insertion, identification and recruitment of an initial user set is a critical step in testing and proving the capability's value. The marketing of such capabilities is a difficult task that most military and Government organizations are not naturally equipped to accomplish; effective liaison with Service and DoD component organizations is required to spread awareness of availability and value.

Evaluation of the results of initial use is essential for understanding the strengths and weaknesses of a technology in production. Not all technologies will survive the tests of use. Those that fail must be quickly identified to prevent continued absorption of scarce resources; those that succeed must be rapidly spread throughout the potential user community on the basis of tangible measures of success. Creation of appropriate measurement techniques and tools is an important early element in the insertion process.

Expansion of the user base by dissemination of proven technologies is the next essential stage. Technology that has been successfully transferred to MCCR applications will require monitoring to assure continuity; the expanding user base will need continuing support for effective application and will provide feedback for continuing improvements.

The technology insertion process has yielded its full value when all potential users have become actual, effective users.

2.4 IMPEDIMENTS TO TECHNOLOGY INSERTION

Mission critical applications impose severe requirements upon supporting technologies that few existing or developing technologies can meet.

Commercial software technologies are not always directly applicable in mission critical software development and support. Although commercial systems (e.g., communications switching, large-scale scientific computations, process control, financial management) may share some of the character-

istics, stringent requirements are often simultaneously imposed upon MCCR systems.

- Size and complexity may be an order of magnitude larger in mission critical systems than in those considered large by commercial standards; MCCR systems containing several millions of instructions are not uncommon.

- Real-time response in the microsecond range is necessary to many missions while millisecond measures are usually the norm in non-MCCR applications.

- Operational environments of MCCR systems are frequently bare and remote from the well-supported host environments in which the software was created.

- Reliability requirements are stringent to the extreme for MCCR systems. Whereas failure of a commercial system may have unpleasant economic or even life-threatening consequences, the failure of a mission critical system may well imperil the defense of the nation.

Economic and societal factors create a climate which damps rather than fosters the propensity to spontaneous change.

- Incentives to undertake the high cost of transferring technology to MCCR applications are apparently insufficient. The profit potential of the DoD software market is evidently not large enough to offer inducement for software technology investments of the needed magnitude.

- Exposure of valuable technology to possible Government data rights claims increases reluctance to invest in or to apply proprietary technologies.

- Risk is seen, rather than opportunity, in employing new technology during MCCR system development. Productivity and quality improvements will occur only over time as paybacks such as growing libraries of reusable software mature, whereas the risks or uncertainties of a new technology are realized immediately.

- Inertia is more comfortable than change. Present practices are seen as working - after all, systems do get built and accepted. Current development and support methods have a wide base of accustomed users within DoD and industry. An impetus for change that outweighs the potential discomfort is needed.

- Insulation, in the sense that military software developers see themselves as a breed apart from commercial software engineers, tends to lessen awareness of developments in universities, research organizations and innovative software products.

Agressive action is needed to bring militarily significant software technologies into central focus. As the MCCR acquisition system is presently structured, business in the private sector offers generally greater profit opportunities than defense business. Market forces work against the needed strategy: new technology development tends to gravitate towards more profitable commercial applications and markets. A sustained and dedicated effort to accelerate technology insertion is required.

2.5 THE TECHNOLOGY INSERTION DRIVER

The SEISP strongly endorses a Software Engineering Institute as essential to the technology insertion component of the STARS strategy. There is a need to develop a mature discipline faster than has ever been done before in any field of engineering.

In the judgment of SEISP members, business as usual approaches, although necessary, will be insufficient to effect fundamental changes in MCCR software development and support within the STARS time horizon. Executive level direction to DOD components to modify policies and procedures towards higher priorities for technological upgrades is necessary. Added funding for technology-oriented development in Service, university and industry laboratories is necessary. Increased emphasis upon software technology in IR&D programs is necessary. Refinement of the requirements for adaptability and reliability in RFP's and contracts is necessary. All of these actions should continue, but by themselves these continued stimuli for evolutionary improvements are not likely to produce integral factors of improvement in productivity, adaptability and reliability for software systems.

There may even be countervailing effects in business as usual. Increased executive attention will of course help, but technological change can neither be mandated nor legislated, and divergent partial solutions could reduce overall effectiveness. Increased technology funding may elicit new concepts, but not necessarily reflect insight into essential MCCR needs; the end effect could be a compounding of the technology selection and insertion task. More aggressive operational software requirements could reduce the pool of competitors if the technology and practice base to meet the requirements were unavailable.

A <u>central driver</u> is needed to:

- Pool scarce resources

- Provide goal-directed technical management

- Select high-payoff, mutually-supportive technologies
- Engineer selected technologies to mission critical scale and quality
- Establish visible standards of excellence in practice and ensure that they are met by the whole MCCR software community

There are two challenges in these needs that differ in kind. The first is to ensure that appropriate technologies are brought into being with the capabilities and robustness required by MCCR applications, which will call for talents and strengths primarily in technical management, technical judgment and technical performance. The second challenge is to ensure that appropriate technologies are routinely employed in the development and support of MCCR software. As well as technical insight, this challenge will call for ingenuity, resourcefulness and skill across whole spectrum of political, economic, organizational and marketing arenas. Developing and executing a strategy to bridge between technology <u>availability</u> and technology <u>application</u> especially within private contracting enterprises is an essential part of the technology insertion process.

The SEISP members believe that a Software Engineering Institute, staffed by the most competent professional minds that can be brought to bear on the engineering of MCCR software, adequately funded, endorsed and supported by the Services and DoD components, will provide the driving force necessary for rapid technology insertion.

3.0 SOFTWARE ENGINEERING INSTITUTE MISSION

The SEISP recommends the following Software Engineering Institute mission statement:

> "The Software Engineering Institute shall provide the means to bring the ablest professional minds and the most effective technologies to bear on rapidly improving the qualities of operational software in mission critical computer systems. The Institute shall accelerate the reduction to practice of modern software engineering techniques and methods, and shall promulgate use of modern methods and techniques throughout the mission critical computer systems community. The Institute shall establish standards of excellence for software engineering practice."

The mission statement emphasizes three essential elements:

- Concentration of a critical mass of professional talent and technology potential.

- Transformation of technology potential into usable and effective methods, techniques and supporting systems.

- Application of methods, techniques and supporting systems throughout the mission critical computer systems community to achieve standards of excellence in practice.

4.0 SOFTWARE ENGINEERING INSTITUTE RESPONSIBILITIES

The Software Engineering Institute supports the goal of an improvement in the qualities of U.S. mission critical operational software that establishes and maintains the clear superiority of U.S. defense and weapon systems.

The Institute's mission is to contribute to that goal by assuring that software engineering practice throughout the mission critical software community achieves and maintains a high level of effectiveness.

To perform its mission, the Institute's principal responsibilities will be:

- Identifying and assessing against needs and opportunities software technologies and technology potential from all sources worldwide.
- Acquiring and engineering high-payoff technologies to mission critical production standards.
- Disseminating engineered technologies throughout the mission critical software community.
- Supporting the Services and DoD components in software engineering matters.
- Educating in support of technology insertion.
- Performing goal-directed research.

The division of Institute effort amongst its responsibilities should reflect their priorities in relation to desired end results. The guidelines below are the SEISP's recommendations for resource allocation proportions.

A major portion of Institute resources should be devoted to the first three of these responsibilities, which together form the core of <u>technology insertion.</u> Approximately 60% of Institute resource should be devoted to achieving rapid reduction to practice of software engineering tools, methods, techniques, processes and environments for MCCR software development and support.

Approximately 20% of Institute resource should be devoted to direct software engineering support of the Services and DoD components. The support function will be a voice of technical authority on the state of the art and the state of the practice, and will set standards of excellence for practice. Some proportion of this resource will respond to requests for consulting services and problem solving in support of programmatic

activities, using these activities as a vehicle for furthering technology dissemination.

Approximately 10% of Institute resource should be directed towards education and training. The Institute will develop and conduct courses teaching the evolving state of the art in MCCR software engineering. It will serve as a seat of influence on software engineering curriculum development throughout the education community. The education function will also serve to accumulate and disseminate the "institutional memory" of the MCCR community.

Approximately 10% of Institute resource should be devoted to goal-directed research in areas judged to be of most essential need and of highest potential payoff. Some level of research opportunity is needed to explore the ideas that the Institute's high caliber of professional staff will generate. Selecting areas that complement the capabilities of acquired technologies will add leverage to a moderate research resource.

4.1 TECHNOLOGY INSERTION PRIORITIES

The SEISP believes that special emphasis needs to be placed upon the technology insertion responsibility with regard to private contracting enterprises.

The needs for technology insertion in both organic DoD staffs and in contracting enterprises are comparable, to improve both the support of existing MCCR software inventory and the production of new MCCR software. But the formal legal, organizational and economic separation between Government and industry represents a particular challenge. The avenues that the Institute can exploit to influence DoD components on behalf of DoD objectives are much richer than those that are available to influence private, autonomous enterprises.

Therefore a responsibility of maximum priority during the first one to two years of Institute operation will be to establish an effective strategy for inserting technology into private MCCR software contracting enterprises. There are no direct links of command and few of exactly shared motive between the DoD and private contractors; the Institute must find effective connections between technology capability and contractors' practices so as to satisfy the DoD need for substantially improved MCCR operational software. The SEISP deliberated at some length over what the elements of such a strategy should be and came to the consensus that there was inadequate time to produce a definitive discussion. Development of a complete, sufficient strategy will require dedicated, full-time attention of executive level management at the Institute. Such a strategy is on the critical line of

Institute success; regardless of success in engineering outstanding software technologies, unless such technologies are routinely employed in contracting enterprises the ultimate goals will not be met.

The Ada[5] program offers an example of a successful insertion strategy. The DoD announced its intentions clearly, published the time frame for requiring Ada and funded base technology development via the AIE and ALS environments. Industry has responded to this strategy by preparing to employ Ada as the technology becomes available and in some cases even appears to be moving faster than DoD schedules. Inserting technologies that delve more deeply into internal software engineering practices will entail greater challenges. The Institute's insertion strategy must demonstrate unequivocally to contractors that software qualities will be <u>required</u> that are unattainable without new technologies or their functional equivalents, and must offer genuine <u>business incentives</u> for contractors to make the necessary investments rather than to withdraw from competition.

Many of the elements this strategy should contain are already discussed in the various functional area strategies of the STARS Program Strategy. The Software Engineering Institute will be the central focus for reaching the pressure points of industrial practice and coordinating the necessary changes in DoD MCCR procurement practices.

---

5 Ada is a registered trademark of the U.S. Government AJPO

5.0 IMPLEMENTATION RECOMMENDATIONS

Evaluating the most appropriate and efficient Institute organization, location, functional relationships and start-up strategy requires selection criteria closely aligned with the Institute's mission and responsibilities.

5.1 ORGANIZATION

The SEISP recommends that the Software Engineering Institute be:

- A dedicated non-profit corporation
- Formally associated with one or more leading universities
- Geographically and organizationally centralized for the first several years

A private non-profit corporation will provide flexibility and independence without unduly constraining avenues of DoD oversight and technical review.

Formal association with one or more leading universities will enhance the intellectual environment and aid in attracting high caliber staff.

The need for fast, effective start-up motivates the recommendation that the Institute be initially centralized. Decentralization options may add to effectiveness once the Institute reaches steady state, but for the critical early years geographic and organizational centralization are necessary to concentrate scarce essential skills and to foster a unity of policy and purpose.

The SEISP considered several alternative institutional models, none of which was completely satisfactory. Other alternatives were:

- Private for-profit corporation
- Federal contract research center (FCRC)
- DoD component
- Contractual relationship with an academic institution or FCRC
- Joint DoD-industry-university organization

Organization under Government auspices was ruled out for two reasons: first, because of the need to offer highly competitive compensation to senior professionals, to maintain stable high-level executive positions over time and to ensure unconstrained interchange between Government, industry and university people; and second, because the time-consuming nature of Government processes conflicts with the need for a functioning Institute in the shortest possible time. Private for-profit corporations entail tax complications and conflict-of-interest exposures. Joint venture approaches have similar legal exposures compounded by anti-trust considerations. (Appendix C analyzes five organizations as candidate models.)

It is important that the Institute operate with a formal relationship with one or more leading universities. The relationship should be mutually beneficial. The Institute offers the university a test bed for software engineering concepts and technologies, a source of adjunct professors, and support for university research. The university offers the Institute faculty and graduate students familiar with software engineering state of art technology and testing and review of the Institute's product technologies.

The centralized approach was chosen by the SEISP after careful consideration of an alternative approach which would begin with decentralization. Decentralization would allow rapid startup because centers of activity could be established in proximity to talent pools. But the approach was rejected because: a decentralized Institute may exhibit an unrealistic view of its own size; the staff requirement may be greater than for the centralized Institute; distributing Institute functions tends to dilute prestige and visibility; distribution of resources tends to diffuse effective leverage on a local industry/political base; and a decentralized Institute will inevitably lack unity of purpose.

5.2 LOCATION

The SEISP recommends that the following criteria guide the choice of the Institute's location:

- Proximity to a major university and to ready sources of professional and support staff candidates
- Ready availability of physical plant, facilities and services
- Sufficient attractiveness to enable recruitment of high level professionals from other areas

- Proximity to a major metropolitan area and transportation hub

- Security from external sources of interference and intrusion

- Separation from sources of day-to-day political and organizational pressures

Choice of location will affect the Institute's opportunities for early success. There must be ready access to users, suppliers, researchers and developers. Since software engineering is a rapidly-evolving discipline, free and convenient collaboration with experts in the field is essential. High caliber management and technical staff must be attracted to the Institute, preferably not all from long distances.

5.3 FUNCTIONAL RELATIONSHIPS

The SEISP recommends that the Institute's formal functional relationships conform with the following criteria:

- Institute oversight at a DoD policy level

- Technical policy guidance at a DUSD level

- Institute contract and funding administration at a Service level

- DoD technology insertion policy guidance at a Joint Logistics Commanders level

- Industrial technology insertion policy guidance at an "Industry Advisory Council" level

- "Board of Visitors" assessment of accomplishments

The DoD Computer Software and Systems (CSS) Directorate will provide a focal point for DoD oversight of the Institute. CSS will be the Institute's principal advocate and sponsor. CSS will provide planning, programming and budgeting support and guidance, and interfaces to OSD elements, other Government agencies, the Secretary of Defense, the Defense Science Board, the Congress and the White House. CSS will also coordinate the Services' STARS activities with respect to the Institute.

The Institute's contract and flow of funding will be administered by a lead Service, which will also coordinate requests from program offices and contractors for technical assistance.

A Board of Visitors will be appointed by DoD, composed of distinguished technical leaders from universities, industry and Government to assess the accomplishments of the Institute.

5.4 START-UP STRATEGY

The SEISP explored four basic alternative strategies together with variations and combinations for applicability to the startup of the Institute:

- Competitive -- Initiate the Institute by issuing an RFP for its creation.
- Special Legislation -- Through an Act of Congress, establish the Institute as an FCRC.
- Invite Initiation by FCRC -- Fund an FCRC to establish the Institute.
- Sole Source (not FCRC) -- Fund a qualified organization (other than an FCRC) to establish the Institute.

Competitive initiation of the Institute tends to satisfy congressional concerns, stimulate concessions and leverage from the competitive bidders, and enhance public awareness and the visibility of the Institute. But there are several serious drawbacks to the competitive alternative. First, the goals of the Institute might be obscured in the clamor for winning the competition. The nature of the competitive cycle might, by itself, discourage participation -- thus, possibly eliminating good choices for Institute location and Director from consideration. Also, competitive procurements are time-consuming. The time criticality of the Institute's mission may make an extended procurement period intolerable.

Legislative creation of the Institute legitimizes the organization and enhances its visibility. Furthermore, a high degree of stability is provided. However, the legislative solution process may be time-consuming and will certainly extract quid pro quo from the Services.

Contract of the Institute to an FCRC will accommodate quick sole-source funding. An FCRC could probably be persuaded to be flexible in selecting staff and a director and in setting of operational policy and procedures. Certain risks accrue to the image of the Institute through association with an FCRC. FCRC's provide minimal public visibility. Existing FCRC's exhibit forms of institutional bias (real or perceived) that would color the operation of the Institute. There is the risk that the Institute might attempt to operate in the "reflected

glory" of a prestigious FCRC instead of quickly establishing its own credentials.

A _sole source contract (not an FCRC)_ has many of the same advantages as contracting to an FCRC. Additionally, a prestigious setting for the Institute providing public visibility can be selected. However, institutional bias and conflict of interest are possible drawbacks. Also, a large sole-source award may require legislative approval.

The SEISP recommends that speed be the primary consideration in selecting a startup strategy. The need for the Institute is critical; it must be established in the shortest possible time.

6.0 CONCEPTS OF INSTITUTE OPERATIONS

Software Engineering Institute operations will require close, cooperative interactions with at least five distinct communities whose interests and operating structures are dissimilar in basic ways:

- the Department of Defense
- DoD contractors
- commercial software and equipment manufacturers
- academic and research organizations
- commercial software-intensive computer resource users

The targets of technology insertion are the DoD contractors who develop MCCR software and the DoD organic staffs who operate and support the software. Potentially useful technology can come from any of the five communities or from the Institute itself. Commercial enterprises whose businesses are completely unrelated to software may be a rich source of internally developed technology. Many potential sources may have no knowledge of DoD software needs nor channels of communication with DoD in their normal business operations.

The Institute must <u>vigorously search for sources of technology.</u> As a standard part of its operations, the Institute must establish and maintain visible and effective communications with all elements of the U.S. industrial complex and the DoD that are concerned with the development and operation of complex software systems.

The Institute must <u>employ effective technology acquisition practices.</u> A comparison of DoD versus commercial aggregate software expense (guessed at perhaps 1:20) suggests that a wealth of technology may reside in enterprises that normally have no contact with MCCR procurement. Institute operations must match acquisition practices to the normal business practices of diverse sources, rather than attempt to force-fit to existing MCCR procurement policies.

The Institute must <u>bootstrap technology insertion.</u> A significant part of the Institute's activity will be the development and adaptation of nascent technologies to produce scaled, production quality facilities for MCCR development and support. As a principal source of these facilities, the Institute will be a critical first link in the chain leading to revolutionary improvements: it must establish impressive schedules and productivities of its own through first use of the technologies it develops to prove their effectiveness to the MCCR community.

The Institute must employ results-oriented technical management practices. The Institute's effectiveness will be measured by the superiority that software-intensive U.S mission critical systems establish and maintain. All Institute operations must be guided by a priority system that places high value on operational results.

The Institute must establish a senior management voice in Congressional, DoD and Service MCCR policy deliberations and decisions. The availability of new production quality software technology is no guarantee that the technology will be effectively applied. The challenge of technology insertion is seldom a wholly technical challenge. Impediments may reside in programmatic, jurisdictional, organizational and procedural considerations to which the Institute can bring a broad, unbiased and results-oriented perspective.

As the central focal point of the five diverse software communities -- DoD, DoD contractors, commercial manufacturers, universities and researcher and large commercial software users -- the Institute will provide a valuable service as a communications and leverage point for the STARS program as a whole.

7.0 ESTIMATES OF REQUIRED RESOURCES

Five year staffing projections are as follows: 80, 130, 180, 220 and 250. These numbers represent the total number of SEI staff to be in place at the end of each respective year; total staff years used for budget projections will be something less than the above numbers. The SEISP believes that this projected buildup can be achieved and must be pursued in order for the Institute to achieve its objectives. The number 250 does not represent a fixed ceiling. Rather, it is the SEISP's estimate of the minimum in-house staff required to sustain operations. Any additional personnel resources required would be obtained via contract and other means.

Based on the 5 year projection for resources, a 5 year project baseline dollar estimate of $8M, $12M, $15M, $20M, and $20M has been derived.

After the first year of operation, the baseline funding falls short of the total required for the Institute. (The differences by year between the total and the baseline are $3M, $5M, $8M, $13M starting at year 2.) The differential funding is to come directly from the Services for products and services provided by the Institute in response to specific needs. A cost model of an existing non-profit corporation was used to project the dollar requirements.

A list of assumptions and a 5 year pro forma cost analysis is contained in Appendix B along with a personnel resource analysis and allocation of personnel by major functions.

8.0 UNRESOLVED ISSUES

The SEISP was unable to completely resolve three issues. Although all are ultimately critical to the successful attainment of the Institute's goals, none is critical to its successful initiation.

- Protection of proprietary rights
- Protection of militarily critical technical data
- Relationship with industry

The issue of the protection of proprietary rights in data and its impact on the success of the Institute is being addressed by a Rights in Data Technical Working Group (RDTWG) recently established by IDA. The RDTWG's report will be delivered to the DoD by October and should address those data rights issues of concern to the Institute.

The issue of the protection of militarily critical data is presently under study by joint Government-industry teams in connection with the DoD funded Export Control Project at IDA. These teams are addressing areas of interest to the Institute.

The SEISP consensus is that to be effective the Institute must have an intense, continuing relationship with industry. This includes sharing of personnel, sharing of technology, joint efforts, and funding. No acceptable plan for creating and sustaining such a relationship was developed. Although direct partial funding of the Institute by industry was rejected, investment by industry of personnel resources and facilities is desirable if such investments do not negatively affect the Institute's responsiveness to DoD needs.

APPENDIX A

SOFTWARE ENGINEERING INSTITUTE STUDY PANEL

Chairman: **Mr. Neil S. Eastman**

Mr. Neil S. Eastman, Manager of the Software Engineering and Technology function of IBM's Federal Systems Division (FSD) served as Chairman of the Software Engineering Institute (SEI) Study Panel. Mr. Eastman has been in the Software Engineering field for the past 22 years, pioneering work in Advanced Software Engineering (SE) areas. He has held numerous software management positions on large DOD contracts and has worked on software metrics, software design methodologies and the automation of software processes in FSD. Currently, he is responsible for software methods and practices as employed by over 2,000 software professionals and FSD's Advanced Technology Program in the field of Software Engineering.

Executive Secretary: **Dr. Robert H. Fox**

Dr. Robert H. Fox, Past Director, Science and Technology Division (STD), Institute for Defense Analyses (IDA), served as Executive Secretary of the SEI Panel. Dr. Fox worked in the area of Military Science and Technology from 1950 until his retirement in 1983. As Director of STD, he played an active role in the direction of studies concerning the applications of computer technology (both hardware and software) within the Department of Defense.

Panel Members:

Dr. Roger R. Bate

Dr. Bate is the Director of the Computer Science Lab at Texas Instruments, Inc. (TI). He is responsible for research conducted in the areas of Artificial Intelligence, speech processing, computer architectures, images, languages and programming environments. Prior to this, Dr. Bate was responsible for the improvement of software productivity with TI. Dr. Bate was a member of the faculty at the Air Force Academy where he was head of the Astronautics and Computer Science Department and Vice Dean of the Faculty. Dr. Bate chaired the Computer Technology Forecast and Weapon Systems Impact Study, COMTEC-2000, which had a significant impact on Air Force policies concerning computers of the future.

Dr. Richard A. DeMillo

Dr. DeMillo is a Professor in the School of Information and Computer Science at the Georgia Institute of Technology. He is the principle investigator for STEP contracts. He

teaches and conducts research in Software Engineering, Computer security, and computer science. Dr. DeMillo has served as a technical consultant to U.S. government agencies and private organizations on such diverse topics as computer security, software technology, commercial applications, software development, and trade secret protection for proprietary software. In the area of software engineering, he has concentrated on software reliability and the emerging area of software metrics.

Joseph M. Fox

Mr. Fox is Chairman of Software A&E, a software firm specializing in software engineering and artificial products and services. He chaired the Navy Embedded Computer Review Panel for the Assistant Secretary of the Navy and was a member of the DoD Instruction Set Architecture Panel and the DoD Defense Science Ad Hoc Committee on Embedded Computers. Prior to his work at Software A&E, Mr. Fox was Vice President of the Federal Systems Division, managing the largest group of programmers in IBM.

Dr. Richard J. Gowen

Dr. Gowen is Vice President and Dean of Engineering at the South Dakota School of Mines and Technology (SDSM&T). At SDSM&T, he has applied his professional experiences to the development of new approaches to quality engineering and scientific education. Prior to this, Dr. Gowen was a member of the Air Force Academy faculty, where he lead the development of the B.S. EE and initiated the sponsored research program. He developed and directed the NASA-DoD Space Medical Instrumentation Laboratory to provide engineering and scientific support to aerospace and electronics industries during the NASA Apollo and Skylab programs. Dr. Gowen serves as an advisor and consultant to government and industry and is the 1984 IEEE president.

Dr. John H. Manley

Dr. Manley is president and founder of Computing Technology Transition, Inc., a young consulting firm which provides software engineering consultation primarily to government agencies. He is also Vice-President for Engineering and Technology for NASTEC Corporation where his primary responsibilities are providing strategic planning and technical marketing direction for a full line of computer-aided systems and software engineering products. Dr. Manley is a recognized authority in software engineering with nearly 30 years of experience in industry, government and academia. Prior to his present work, Dr. Manley was Corporate Director for Programming Applied Technology at ITT where he was

responsible for program technology worldwide. Dr. Manley also spent 20 years in the Air Force and was Assistant to the Director of the Applied Physics Lab at Johns Hopkins University as well as a visiting professor in the EE Department at the university.

Mr. Alfred M. Pietrasanta

Mr. Pietrasanta, as Director of the IBM Software Engineering Institute, is responsible for a curriculum of courses on modern software engineering and computer science being offered to the IBM systems programming professionals. A major focus of the Software Engineering Institute is on software design methodology to achieve high quality and productivity. Mr. Pietrasanta is also responsible for the New Technical Higher Education, which will provide several education courses to new professionals in IBM labs and plants during their first 18 months after hire.

Dr. Sam Steppel

Dr. Steppel is the senior member of the executive staff at Computer Sciences Corporation (CSC). He is on the staff to the President, CSC Systems Group and has oversight of the system development efforts within this group. He is the coordinator of the CSC Technology Task Force which analyzes new technology and its impact on computer system development. Dr. Steppel has been tracking new technology advancements, such as STARS and Ada, and directing the preparation of CSC's comprehensive system development methodology. With over 12 years of experience in developing computer-based systems, past experiences include the design and development of systems for NASA and managing a NASA facility. Dr. Steppel was also employed by Stanford University and the European Center for Nuclear Research.

Mr. Keith Uncapher

Mr. Uncapher is Executive Director of the Information Sciences Institute (ISI), Associate Dean in the School of Engineering, and Professor of Computer Science at the University of Southern California (USC). Mr. Uncapher is the founder and director of the ISI, which has become one of the country's four leading university-based Information Processing Research Centers. It provides, within a university, a systems-oriented problem solving research environment, with expertise in the application of information processing science and technology, to major user areas.

Dr. Barry H. Whalen

Dr. Whalen is President of WAFER TEC, a hardware company that is applying advance integrated circuit technology to

high performance small computers. Prior to this, Dr. Whalen spent 20 years at TRW. As VHSIC Project Manager, he was responsible for the definition and design of very high integrated circuits and brass board processors. Dr. Whalen was responsible for planning and marketing advance technology for computers, communication and electronic warfare when he was Special Assistant to the General Manager, Military Electronics Division, TRW. Other accomplishments include: manager of software development projects for the Gemini and Apollo spacecrafts and several military satellite systems; developed the Vernier guidance software for the Atlas ICBM; and member of the National Materials Advisory Board on VHSIC.

Dr. Charles H. Wilcox

Dr. Wilcox has been with Hughes Aircraft for 30 years. During the first 15 years, he worked at the Hughes Corporate Research Labs conducting Artificial Intelligence research. Later he served as Director of IR&D for the total company and then as Director of Engineering for the Aerospace Group. Dr. Wilcox is presently the Corporate Director, Technical Management, where he provides company leadership and oversight for software engineering and CAD/CAM at Hughes. He also coordinates the military requirements planning for the total company and has served on several other panels for the government.

Dr. William Wulf

Dr. Wulf is one of the founders and President of Tartan Laboratories. This relatively new company is involved in the development of high technology software. Specifically, system software that is intended to enhance programmer productivity, including compilers, editors, debuggers, profiles, etc. Formerly a professor of computer science and acting department head at Carnegie-Mellon University (CMU), Dr. Wulf was responsible for the design of BLISS (a systems programming language), C.mmp (a 16-processor multi-processor), hydra (a capability-based operating system with emphasis on utilizing parallellism in C.mmp and on protection and security) and Alphard (a programming language with emphasis on data abstraction and program verification).

DoD STEERING COMMITTEE

Dr. Edward Lieblein
Acting Director (Computer Software & Systems),
ODUSD (R&AT)
(Study Monitor)

Colonel J. Frank Campbell, USA
Headquarters, DARCOM (DRCDE-SB)

Lt. Colonel Larry E. Druffel
Special Assistant to DUSD (R&AT)

Mr. Robert M. Hillyer
Director of Navy Laboratories/NAVMAT-05

Dr. Bernard Kulp
Headquarters, AFSC/DLZ
Andrews AFB

Major General Emmett Paige, Jr.
Commanding General
Headquarters, U.S. Army
Electronics Research & Development Command

INSTITUTE FOR DEFENSE ANALYSES

Mr. Norman D. Jorstad

Mr. Jorstad is a Research Staff Member in the Science and Technology Division of the Institute for Defense Analyses (IDA). His expertise in export control, system integration and design of computers, teleprocessing, communication and command and control systems has influenced many IDA reports and papers. Presently, Mr. Jorstad is developing a plan for the improvement of DoD acquisition procedures. Before coming to IDA, Mr. Jorstad was president and principal consultant for JORAD Associates.

Professor Thomas C. Bartee

Professor Bartee is on the teaching staff of the Aiben Computation Lab at Harvard University in the Department of Engineering and Applied Physics. As a consultant to the Institute for Defense Analyses, Professor Bartee was on the President's Commission on Law Enforcement and Administration of Justice, Technical Subcommittee, studying data processing systems for the Department of Justice. At IDA, he also participated in several studies of computer networking, especially concerned with protocols, system organization and distributed processing.

Dr. Thomas H. Probert

Dr. Probert is Director of the newly established Computer and Software Engineering Division at the Institute for Defense Analyses. Dr. Probert has been actively involved with the Ada Joint Program Office since 1981 and with the

STARS Program Office since its establishment. Dr. Probert was responsible for the establishment of the Ada Validation Organization at IDA and has played the major role in developing and leading the growing IDA program aimed at providing the DoD and the relevant computing community the technical assessment and support necessary to maintain international leadership. Prior to joining IDA, Dr. Probert was a Technical Staff Member at the MITRE Corporation, where he was responsible for the development of the methodology for validating Ada compiler for the DoD.

APPENDIX B

SEI RESOURCE JUSTIFICATION

LIST OF ASSUMPTIONS

SEI COST ANALYSIS*

I. Staffing

A. Level — based on midyear staffing each year: (year 1: 42; year 2: 105; year 3: 156; year 4: 201; year 5: 237)

B. Ratio — 2 senior research personnel to 1 support personnel

C. Salary

	Year 1	Year 2	Year 3	Year 4	Year 5
Senior	60K	55K	55K	60K	65K
Support	25K	27K	29K	31K	33K

Estimates are based on the initial hire of very high level people. Cost-of-living is incremented at approximately 8%/year.

D. Fringe Benefit Rate - 22% of salaries each year (not including paid vacation).

II. Other Direct Costs (includes 6% COL)

A. Travel, materials and supplies per senior personnel.

B. Common costs as a percentage of total salaries (categories include materials and supplies, travel, communications).

C. Administrative costs which include a percentage of administrative salaries, and related space, travel and material and supplies costs.

III. Indirect Costs

A. Overhead rate - 37% each year.

---

*The particular cost parameters given (e.g. overhead) relate to a specific accounting system which varies from organization to organization. However, total cost derived is relatively invariant to changes in accounting systems.

IV. Facility Costs

A. General workspace based on percentage of salaries at a rate of $2/sq. ft./month (includes a library, classrooms, conference rooms and laboratories). (Total space of 70,000 sq. ft. in year 5.)

B. Computer support - includes operations and maintenance costs, and equipment amortization costs at 20%/per year.

C. Network operations and maintenance - an estimate of the costs involved per year (includes 6% COL each year).

V. Startup/Expansion Costs

A. Computer room buildout - only a startup cost.

B. Laboratory buildout - based on general workspace dollars.

C. Network equipment acquisition costs - an estimate of the initial expense required.

D. Office equipment and furniture - based on $2K per new hire.

E. Computer equipment acquisition - based on $40K per senior new hire and $30K per support new hire, plus the cost of $1KL (years 1-3) and $2KL in years 4 and 5.

F. Equipment installation - based on an estimate for phone system, copiers and terminal installation.

G. Personnel relocation - 50% of senior new hires would be relocated.

SOFTWARE ENGINEERING INSTITUTE

PRO FORMA COST ANALYSIS

	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
BASELINE $	8.0M	12.0M	15.0M	20.0M	20.0M
TARGET YEAR-END HEADCOUNT	80	130	180	220	250
PERSONNEL COSTS	4280154	9804180	14743614	20530171	25808039
FACILITY COSTS					
WORKSPACE (INCLUDES LAB, CLASSROOM, OFFICES, LIBRARY)	450512	1029774	1545627	2155936	2715889
COMPUTER SUPPORT	1180000	2087800	2877552	4341563	5035988
NETWORK O&M	65000	68900	73034	77416	82061
*TOTAL FACILITY COSTS	1695512	3186474	4496213	6574915	7833938
**ANNUAL OPERATING COSTS	5975666	12990654	19239827	27105086	33641977
STARTUP/EXPANSION COSTS					
COMPUTER ROOM BUILDOUT	235000	0	0	0	0
LAB BUILDOUT	30000	50000	40000	40000	50000
NETWORK EQ. ACQUISITION	70000	0	0	0	0
OFFICE EQ. & FURNITURE	84000	133560	114597	107190	90900
COMP EQ. ACQUISITION COSTS	2140000	2310000	1870000	2250000	1320000
EQ. INSTALLATION COSTS	50000	0	0	0	0
PERSONNEL RELOCATION	18200	28938	24837	23235	19704
*TOTAL STARTUP COSTS	2627200	2522498	2049434	2420425	1480604
**TOTAL	8602866	15513152	21289261	29525511	35122581
LESS AMORTIZATION	-428000	-890000	-1264000	-1714000	-1978000
**TOTAL FUNDING REQUIRED	8174866	14623152	20025161	27811511	33144581

PERSONNEL RESOURCE ANALYSIS

	Year 5	
Total Headcount	250	
Indirect (one third)[A]	83	
Direct (two-thirds)	167	
		250
Directs by Major Function[B]		
Technology Insertion (60%)	100	
Technical Support (20%)	33	
Education/Training (10%)	17	
Research (10%)	17	
		167
Directs on Technology Insertion[C]		
Identify, Select Technology	15	
3 Pilot Projects @ 20	60	
3 Evaluations, Qualifications @ 5	15	
Demonstrate, Market	10	
		100

Notes:

[A] Indirect percentage based on some comparable laboratory examples. Consists of managers, secretaries, administration, computing center.

[B] Percentages of effort by major function are approximate.

[C] This is an example only of Technology Insertion activities, to illustrate approximate levels of effort that might be anticipated. Pilot projects consist of technology re-engineering, testing, scale-up, validation, methodology definition, etc.

APPENDIX C

INSTITUTIONAL TYPES CONSIDERED

A summary of the features of the five existing institutions selected by the Panel for further examination is contained in this section. These institutions are:

- Lincoln Laboratory (LL) - University based, Tri-Service
- Naval Research Laboratory (NRL) - Navy-Corporate laboratory
- National Center of Atmospheric Research (NCAR) - University-consortium
- Electromagnetic Compatibility Analysis Center (ECAC) Joint Service-non-profit technical support
- Applied Research Laboratory (ARL) - Navy-University laboratory

LINCOLN LABORATORY

FEATURES:

- o University component, strong coupling at top management level
- o Tri-Service and DARPA overall program review and direction
- o Advanced electronics R&D mission
- o Strong emphasis on staff quality
- o Both hardware and software products
- o Many individually contracted efforts for Service elements
- o Not exposed to on-campus student and faculty politics

DOES NOT:

- o Have industry support or functional involvement
- o Interface functionally with unversity community

NAVAL RESEARCH LABORATORY

FEATURES:

- o Navy corporate R&D organization
- o Annual review by Naval Research Advisory Committee
- o Industrial funding, competes within Navy for funds
- o Sensitive to needs of systems commands
- o Technical review primarily internal
- o Primary emphasis on R&D

DOES NOT:

- o Have strong university involvement
- o Have strong industry involvement
- o Have ready access to high-level slots

NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

FEATURES:

- Operated by university consortium non-profit corporation
- Challenging mission
- Parent organization consists of entire atmospheric research community
- Parent organization has delegated responsibility from NSF for major portion of NSF atmospheric research program
- Research focus

DOES NOT:

- Support military needs, except indirectly
- Functionally involve industry
- Concern itself with technology insertion

ELECTROMAGNETIC COMPATIBILITY ANALYSIS CENTER

FEATURES:

- o High level OSD program oversight
- o Tri-Service technical management, staffing
- o DoD-wide responsibilities
- o Strong technical support from non-profit organization
- o Interactive tasking by Service Program Office
- o Full cost reimbursement by users
- o Base funding to maintain capabilities
- o Emphasis is analysis and software, large model development

DOES NOT:

- o Have university involvement
- o Have industry involvement
- o Have emphasis on technology insertion

APPLIED RESEARCH LABORATORY

FEATURES:

- Univeraity component, not degree-granting
- Broad-based University Advisory Board, sponsor participation
- Close involvement with university
- Industrially-funded program, primarily for Navy
- Emphasis on technology base advancement
- Limited industrial support, with sponsor permission
- Emphasis on staff quality
- Both hardware and software products

DOES NOT:

- Have multi-university involvement
- Have Tri-Service emphasis
- Have technology insertion emphasis
- Have large industry involvement